EST - **eni** Slurry Technology

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eni Slurry Technology

EST: maximizing refinery profitability through heavy feeds upgrading

In the next few years, the current trend in both upstream and downstream sectors will continue to require new technologies which are able to convert heavier and heavier feedstocks into high quality transportation fuels.

Today a hydrogen addition route is likely to be the right choice due to high conversion, high diesel selectivity and Euro V grade products. However, conventional hydrocracking solutions like fixed bed and ebullated bed technologies suffer from limitations on feedstock quality as well as problems related to residue stability that limit the maximum conversion achievable.

eni Slurry Technology, the real breakthrough hydrocracking process developed by **eni**, is the response to the needs for increased distillate yield and bottom-of-the-barrel-conversion.

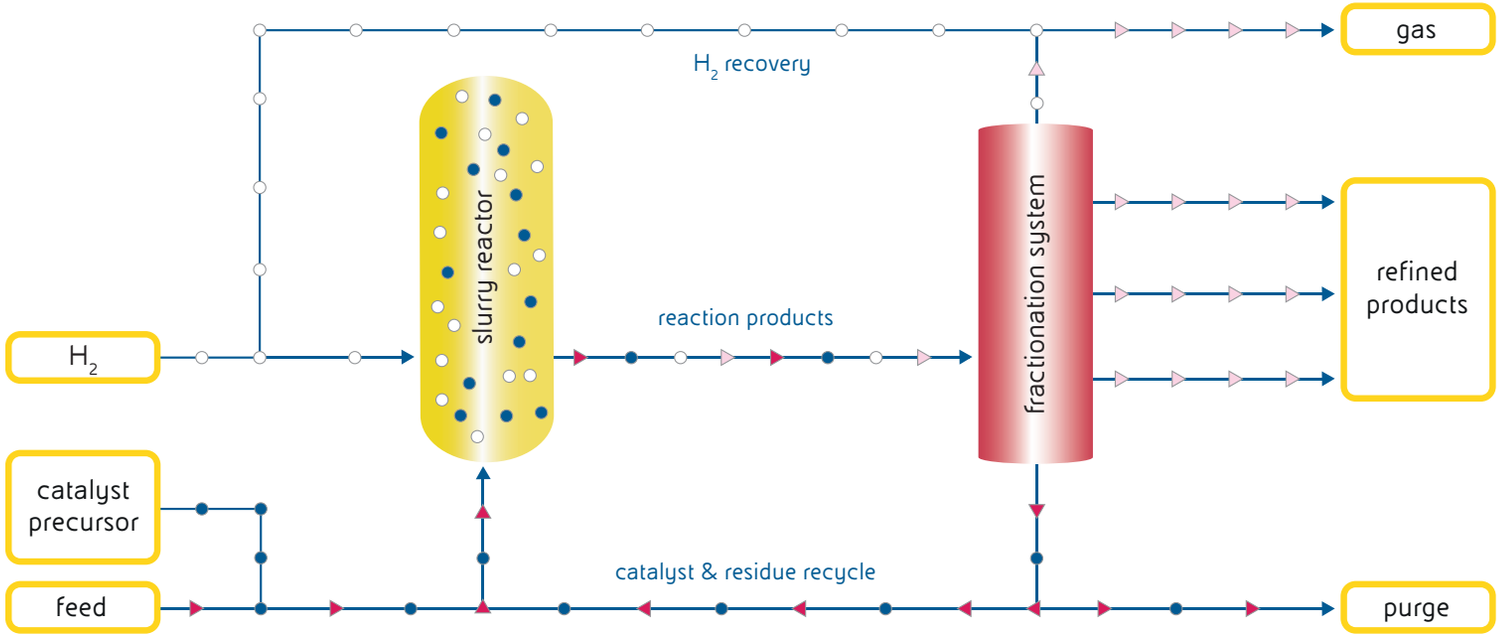
eni Slurry Technology: key features

EST is a hydrocracking technology featuring:

- a very active, dispersed, non-ageing, slurry catalyst, which prevents coke formation and promotes upgrading reactions (sulphur, nitrogen and metals removal and CCR reduction)
- a slurry bubble column reactor developed in-house, perfectly homogeneous and isothermal. EST reactor favours optimal control of exothermic hydrocracking reactions, thus increasing energy efficiency at the same time
- a fractionation section for the recovery of the light, middle and heavy distillates
- an innovative process scheme that allows catalyst to be recycled in a very simple and economic way.

This process scheme allows the almost complete conversion of the vacuum residue, overcoming the main limitation of commercially available conversion technologies, i.e. the threshold for the phase separation of the asphaltenes.

Only a small purge is necessary to limit the build-up of metals (Ni and V) present in the heavy feedstock. Therefore, EST provides higher yields over current available conversion technologies. Moreover, EST offers significant advantages in terms of efficiency of hydrogen utilization and catalyst life, achieving longer cycle length compared to resid hydrocracking solutions currently being marketed.



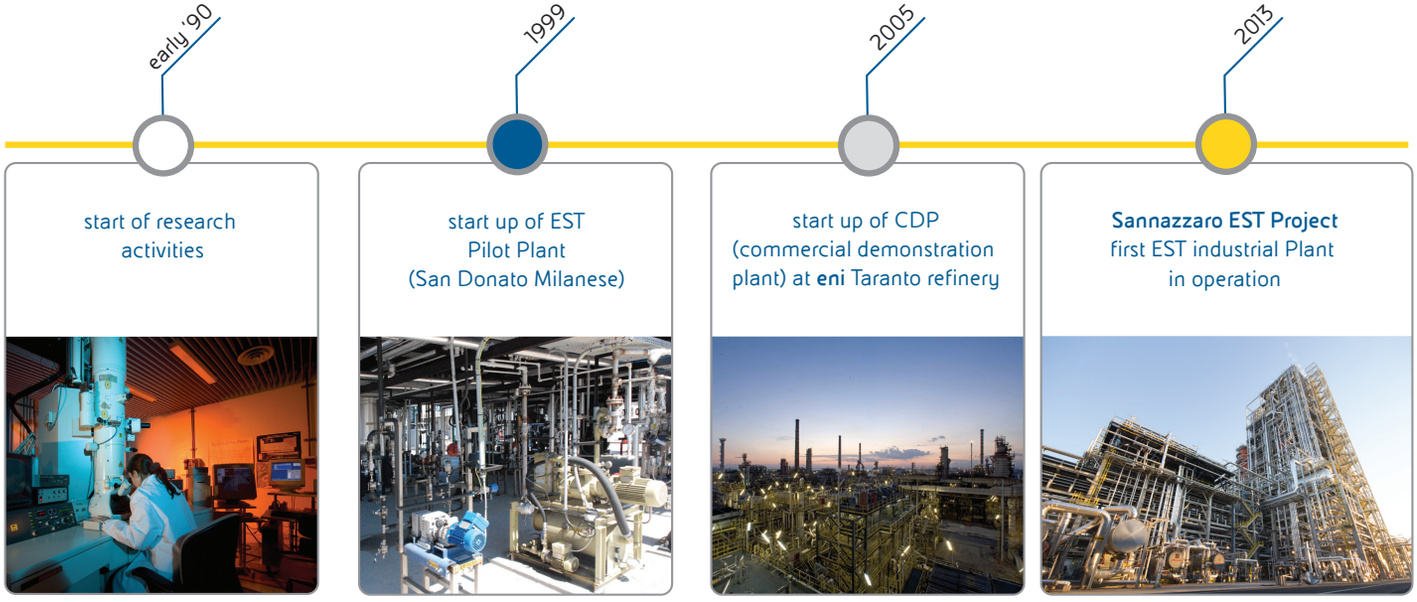
EST simplified process scheme

EST development path

After an intensive R&D activity carried out at laboratory level, a pilot plant was built and operated at **eni**'s San Donato Milanese facilities, in order to demonstrate the technical feasibility of the process.
The results were extremely positive thus **eni** approved the investment for a commercial-demonstration plant (CDP) of 1,200 BPD capacity. The selected location was **eni**'s Taranto refinery. Construction started in 2003 and was completed at the end of 2005. Since then, the CDP unit has been operating successfully with a wide range of feeds: conventional crude vacuum residues, bitumens from Canadian oil sands, extra heavy oils and visbroken tars. The preliminary economic evaluation, based on the test results, confirmed the attractiveness of the EST approach, which led to the decision for the first industrial application. **eni**'s Sannazzaro refinery has been chosen to host the first full-scale industrial plant based on EST technology.

The CDP operation has been crucial for developing and consolidating the know-how on EST technology confirming the expected process performance obtained at the pilot scale.
Moreover the CDP experience has taught us:

- to learn how to tailor the technology with different feedstocks
- to develop and fine-tune process simulation models
- to develop and test operating procedures for start-up, steady-state operation, shutdown and emergency conditions
- to train operation and maintenance personnel
- to train process engineers
- to evaluate the performance of selected construction materials against corrosion in harsh environments
- to evaluate the performance of different kinds of instrumentation with heavy, fouling fluids



EST development main milestones

the first industrial application: Sannazzaro EST Complex

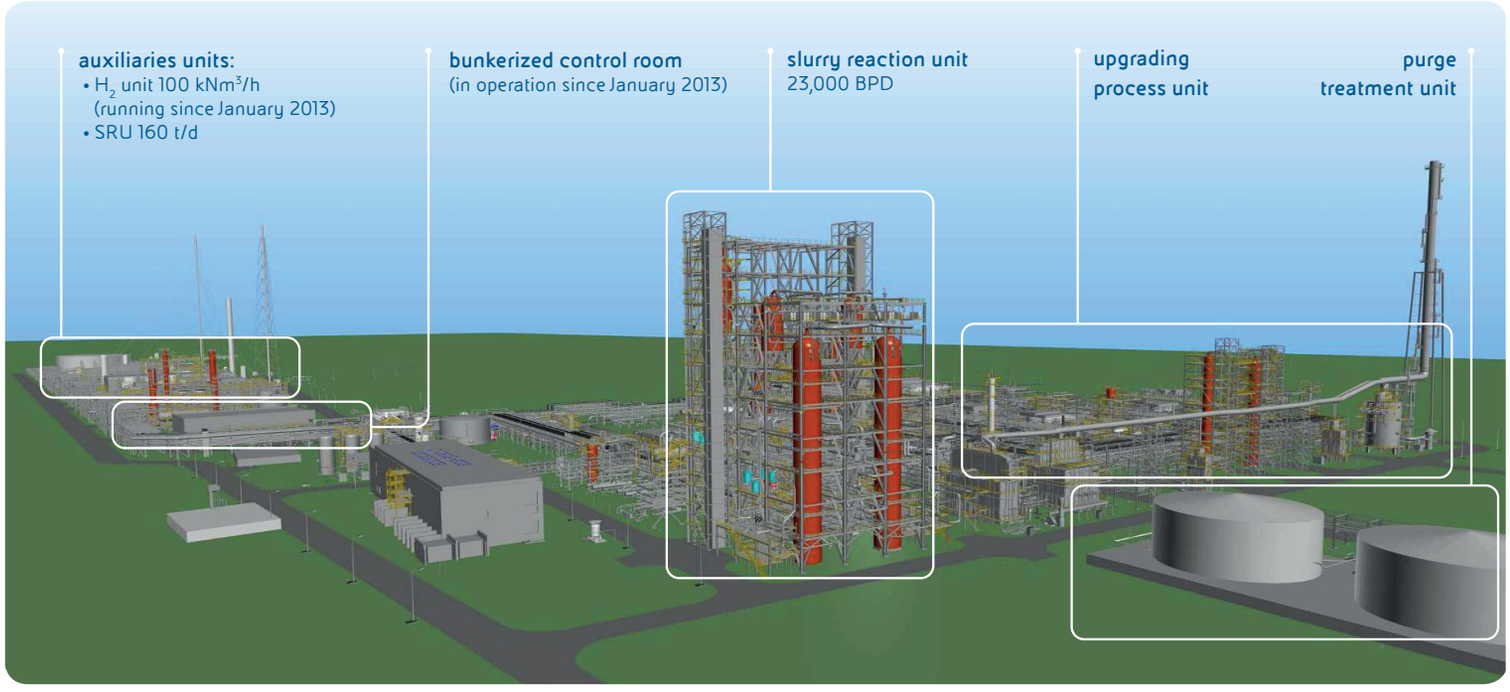
The first industrial application of **eni** Slurry Technology is the EST Complex in **eni**'s Sannazzaro de' Burgondi refinery.

The EST Unit has a design capacity of 23,000 BPD and allows the Sannazzaro refinery to convert the bottom-of-the-barrel into Euro V diesel and other valuable refinery streams (LPG, naphtha, jet fuel,...).

The plant also represents the first full-scale industrial plant in operation based on a slurry hydrocracking process: the new EST Unit has successfully and safely begun operations in the last quarter of 2013 (oil-in: October 14th).

EST configuration incorporates the most advanced technical solutions and all the operating experience achieved in more than eight years of continuous tests and operations in the Demonstration Plant at **eni**'s Taranto refinery.

Many innovations have been brought to the Project, from special items to the up-to-date construction methodologies which have made extensive use of the pre-assembly of large structures, foundations and even process heaters. Reactors of maximum size in terms of internal diameter and weight have been installed to establish a reference for future industrial initiatives.



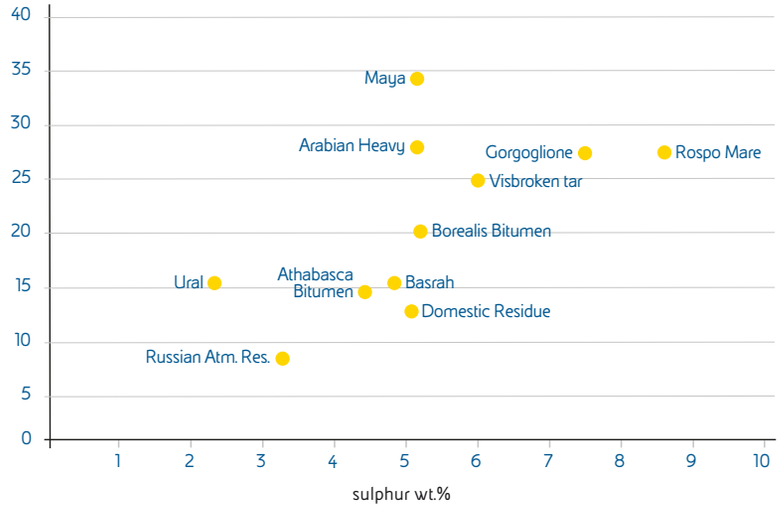
EST Complex layout (3D model)

high conversion and feedstock flexibility

eni Slurry Technology can process a wide variety of feedstocks: atmospheric and vacuum residues, heavy and extra-heavy oils, bitumen from oil sands, de-asphalter bottoms, visbroken tars, coal liquids and other high-boiling feedstocks.

The excellent flexibility of EST has been widely demonstrated on pilot and demonstration units and a conversion higher than 97% was achieved in all experimental runs.

EST technology does not show any limitation due to metals content and asphaltenes, sulphur, nitrogen and other contaminants concentration.



EST Feedstocks (pilot and demonstration units)

EST in downstream and upstream industry

The EST process has considerable market potential for both upstream and downstream applications.

Thanks to the extremely high feed flexibility, EST could be the solution for the profitable exploitation of the huge reserves of unconventional oils, ensuring the availability of additional strategic reserves.

In addition, EST can also be considered an option for the valorization of natural gas reserves which could be properly utilized to produce hydrogen for the EST process as well as to provide the energy requirements for the process.

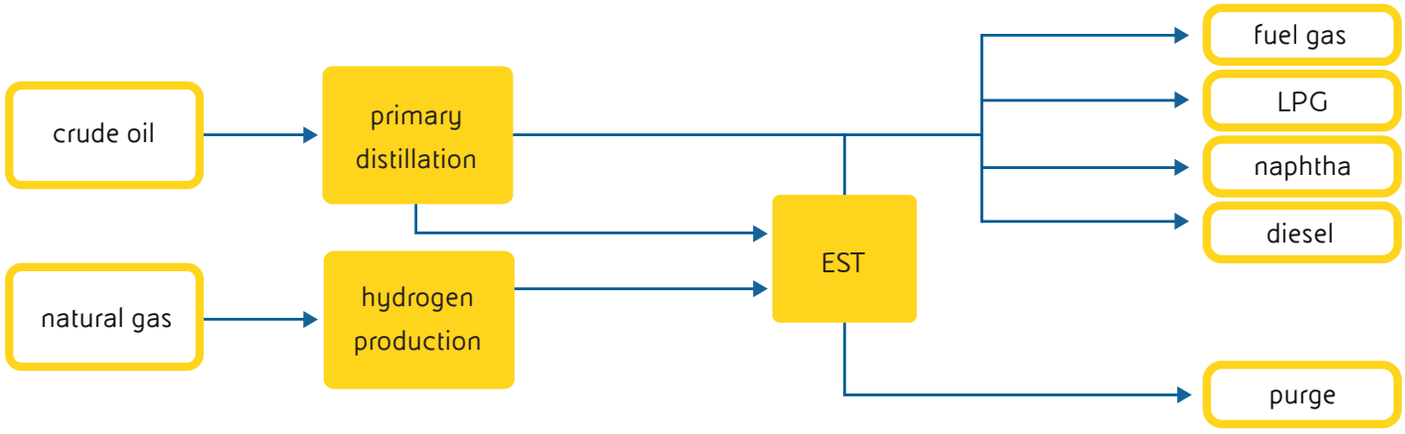
On the other side, the refining industry could benefit from EST to solve the problem of bottom-of-the-barrel upgrading in a very efficient way.

> upstream

- valorization of increasingly heavier oils worldwide
- more profitable marketability of the world huge reserves of extra-heavy oils
- elimination of upstream low-value petcoke production
- valorization of natural gas through high quality syncrude production

> downstream

- meet the declining demand of Fuel Oil by converting surplus of refinery residues into distillates (Zero Fuel Oil-Zero Coke Refinery)
- meet the increasing demand of cleaner distillates without increase of the CDU capacity
- increase the refinery flexibility to supply of heavier crudes



EST refinery overview

EST integration in existing refineries and synergies with other process units

One of the most significant advantages of EST is the possibility of integration into existing refineries, creating synergies with existing plants and facilities and minimizing the level of new investments CAPEX.

EST can produce finished products with the presence of a dedicated upgrading section; however, if spare capacity in an existing hydrotreater is available, the new investment may comprise only the slurry hydrocracking and separation section.

EST benefits and future perspectives

EST, the first industrially proven slurry hydrocracking technology, offers a unique solution to radically modify existing refinery schemes and open new perspectives in the oil business.

Main benefits from utilizing EST include:
- feed flexibility
- high conversion to light and middle distillates (or upgraded syncrude in upstream contexts)
- premium, environmentally-clean fuel production
- demonstrated reliability
- environment-friendly technology (coke or fuel oil production reduced/eliminated)
- high energy efficiency
- excellent option for natural gas valorization.

Most recent EST improvements have been addressed to simplify the process cycle, therefore:
- reducing CAPEX and OPEX
- decreasing specific energy consumption
- increasing reliability.

eni is a major integrated energy company, committed to growth in the activities of finding, producing, transporting, transforming and marketing oil and gas. The company has global operations in 85 countries and employs about 82 thousand people.

eni's strong presence in the gas market and in the liquefaction of natural gas, consolidated skills in the power generation and refinery activities, strengthened by world class skills in engineering and project management, allow the company to catch opportunities in the market and to realize integrated projects.

eni's business model for the creation of sustainable value is founded on a consolidated operating model in a framework of clear rules of governance using the highest ethical standards and rigorous enterprise risk management.

When implementing its strategy and running its day-to-day operations, **eni**'s efforts are inspired by these key drivers: cooperation, integration, innovation, excellence, inclusion, responsibility. In 2013 **eni** confirmed its presence in the Dow Jones Sustainability Indices and in the FTSE4Good index.

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EST is delivered by an operator to an operator

The key to **eni**'s success as EST licensor is the knowledge achieved from the company's experience as the owner and operator of the first EST industrial plant.

EST technology has been developed and fine-tuned after many years of experience operating the Commercial Demonstration Plant and, more recently, the industrial plant.

This gives clients access to the latest developments and best practices that have taken time to evolve, thus offering a competitive advantage compared to other technologies available on the market.